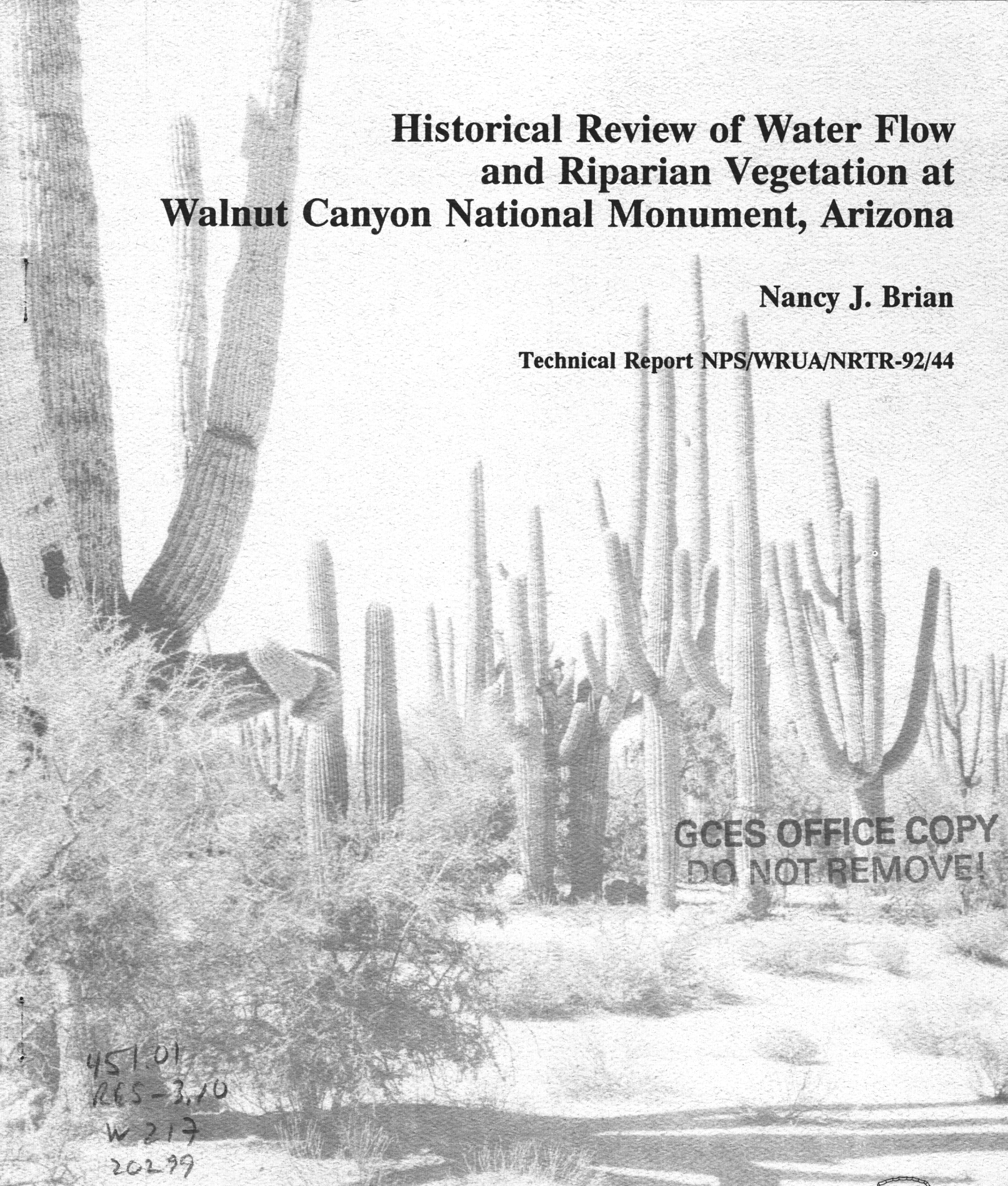
Historical Review of Water Flow and Riparian Vegetation at Walnut Canyon National Monument, Arizona

Nancy J. Brian

Technical Report NPS/WRUA/NRTR-92/44



United States Department of the Interior
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Cooperative National Park Resources Studies Unit
The University of Arizona ♦ Tucson, Arizona

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May 1992

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ABSTRACT

The history of hydrology and riparian vegetation in Walnut Canyon National Monument, Arizona, since the 1900s is described. A literature review and a survey involving comparison of present-day photos with historical photographs were conducted to ascertain the hydrologic history of Walnut Canyon and to document changes in vegetation since the turn of the century. I found (1) no evidence that Walnut Creek was a perennial stream prior to the construction of the Lake Mary Dams and (2) that riparian vegetation has increased dramatically in Walnut Canyon since 1949.

INTRODUCTION

The purpose of this study was twofold: (1) to ascertain the hydrologic history of Walnut Canyon and (2) to document any changes in vegetation since the turn of the century. Water flow in Walnut Creek is documented through a historical, chronological literature review. Vegetation change within the riparian (streamside) zone was assessed by comparison of 1985 photographs with historical photographs of the riparian zone and areas above Walnut Creek.

STUDY AREA

Walnut Canyon National Monument (WACA) is located approximately 11 km (7 mi) southeast of Flagstaff, Coconino County, Arizona, within T. 34 N. and R. 8 E. (U.S. Geological Survey 1962, 1968). The monument encompasses 908.6 ha (2,245 a) (Walnut Canyon National Monument 1976). Walnut Canyon National Monument, known foremost for its archeological remains, was named for the walnut trees (*Juglans major*) that grow along the canyon bottom (Colton 1932). Originally, the area was part of the San Francisco Mountain Forest Reserve (Shimer and Shimer 1910) established in 1898 and administered by the Forest Service, U.S. Department of Agriculture. In 1906, President Theodore Roosevelt set aside 3.9 km^2 (1.5 mi^2) as a national monument (Colton 1932), and on November 30, 1915, President Woodrow Wilson established it as a national monument under the jurisdiction of the National Park Service, U.S. Department of the Interior (Colton 1932). The boundaries were enlarged September 24, 1938, by President Franklin D. Roosevelt (King 1941).

Walnut Creek[1] drains 326.3 km^2 (126 mi^2) of the Mormon Mountain watershed (Schuyler 1909). The drainage (Fig. 1) begins north of Mormon Lake (T. 19 N., R. 9 E.) in what was originally known as Clark Valley (Barnes 1935). Water enters Upper Lake Mary, which then flows into Lower Lake Mary. The creek bed curves around the northwestern edge of Anderson Mesa, turns northeast and zigzags through a 121.9-m (400-ft) deep canyon carved in the Permian deposits of Kaibab Limestone and Coconino Sandstone. The drainage name changes to San Francisco Wash at its juncture with the Santa Fe Railroad near Winona just north of Interstate 40 (T. 21 N., R. 8 E., Sec. 10), then empties into Diablo Canyon, which in turn flows into the Little Colorado River drainage.

[1] At least 5 drainages are named "Walnut Creek" in Arizona (Granger 1983). Walnut Creek in Walnut Canyon National Monument, Coconino County, should not be confused with the creek in Yavapai County which drains into Big Chino Wash (Salt River drainage); the creek in Gila County that drains into Spring Creek (Salt River drainage); the creek in Navajo County that drains into Silver Creek (Little Colorado drainage) (Silvey et al. 1984); or the creek in Mohave County (Granger 1983). To further confuse the unwary, there are 7 Walnut canyons in Arizona (Granger 1983): 2 each in Cochise County (T. 14 S., R. 27 E. and T. 22 S., R. 29 E.) and Coconino County (WACA and T. 21 N., R. 8 E.); 1 each in Gila County (T. 6 N., R. 10 E.), Greenlee County (T. 6 S., R. 30 E.), Navajo County (T. 10 N., R. 20 E.), and Pinal County (T. 3 S., R. 12 E.).

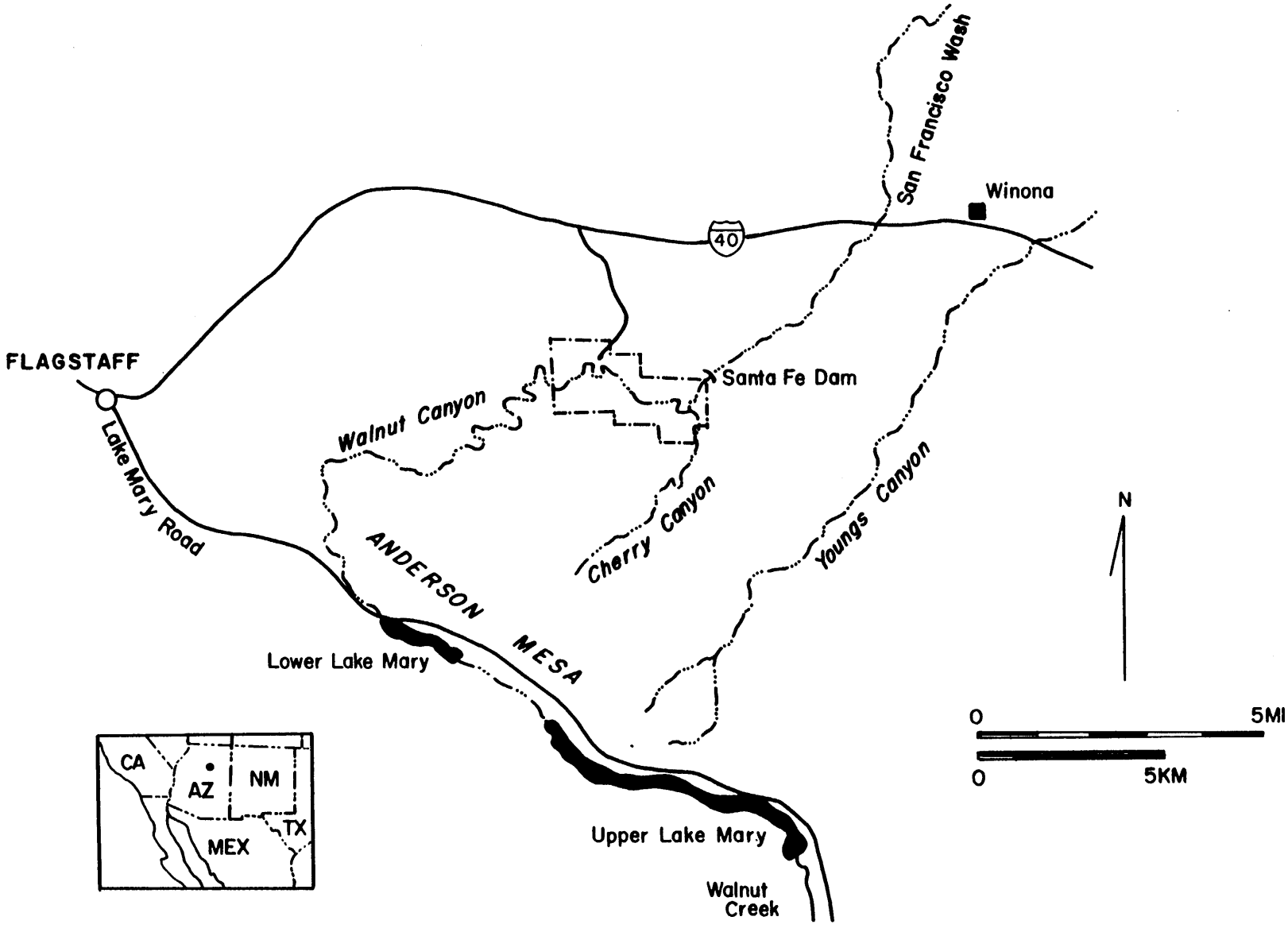

Figure 1. Map of Walnut Canyon National Monument, Arizona, and environs.

CHRONOLOGICAL LITERATURE REVIEW

METHODS

Literature searches were made at the Main Library and Special Collections Library of Northern Arizona University (NAU), Coconino County Library, Museum of Northern Arizona Library, and the WACA library. Specific statements about water flow found during the review are cited. These citations range from 1853 to the present. Literature pertaining to flora and fauna is also cited, but archeological references are not included.

RESULTS

Evidence concerning the pre-historic flows of Walnut Creek comes from 3 sources. First, Clark (1968) compared vegetation on archeological sites with non-site locations at WACA. The author stated, "The domestic water [for the Indian inhabitants living in WACA during the 1000s to late 1200s] was a stream flowing in the canyon bottom, 400 feet below the rim."

Second, a visitors' guide to WACA (Southwest Parks and Monuments Association 1971) stated that a maximum population of 400-500 Sinagua Indians inhabited the canyon from A.D. 1120 to 1250. In reference to water, the publication stated, "A stream, probably 1.2 or 1.5 m (4 or 5 ft) deep, flowed in Walnut Canyon when the Indians came here presumably year round. . . One likely cause of abandonment was drought. With only a slight decline in annual rainfall, or not enough rain in the growing season, the stream would have failed. . . Tree-rings reveal 23 years of drought in the Southwest from A.D. 1276 to 1299; Walnut Canyon dwellers were gone by that time, perhaps forced out by earlier droughts of less duration."

Finally, a natural and cultural resources management plan and environmental assessment (Walnut Canyon National Monument 1976) stated that water flowed through Walnut Creek until 1904 and that "Today, the canyon is dry except for what water may collect in small pools from spring runoff and during periods of particularly hard rains."

Only 4 historic references found during the literature search predate the construction of Lower Lake Mary. In 2 references, the permanent water at Turkey Tanks was discussed. The first is by Lieutenant A. W. Whipple who passed north of WACA while exploring for a railway route from Fort Smith to Los Angeles in the years 1853 and 1854. He noted:

> The pool of water in the canyon below the caves (Cosnino) seems to be supplied from a spring. It has afforded sufficient [water] for our large herd, above 200 mules, and appears to suffer little diminution. The fact of

> a good-sized Indian village having been established in the vicinity, is in itself a strong indication that the water is unfailing (Foreman 1941).[2]

A few years later, in 1857-1858, Lieutenant E. F. Beale travelled Whipple's route. He noted a similar situation at Turkey Tanks:

> At 4 we came to the banks of a rocky canon, in which we found abundance of wood and water. Judging from the number of Indians who had evidently made this place a resort, I should think water might be found here at all times. . . The creek on which we are camped is fringed with black walnut of remarkably close texture, and many of them of considerable size. September 10, Camp 11: Thornburn and I crossed ahead to explore, and found fine, clear water, about a mile from camp, in very much such a place as we discovered it last evening. . . This morning we left camp, and following up the little valley. . . and came around it to the water we had discovered this morning, which, on examination, proved to be the same canon on which we had encamped last evening, and which was also one of Whipple's camps in 1853. . . On further examination of the creek I found water in abundance, both above and below where we stuck it this morning, and I think it quite likely it may be found here at all times (Beale 1858).

On his return through the area on February 5, 1858, Beale noted, "If any one should ever follow our trail, it must be remembered that the water at this point is not that found at our wagon camp at the caves, although that is generally sufficient, but in an immense tank a quarter of a mile or so below." He described the tank as being 2.4-3 m (8-10 ft) deep, 6 m (20 ft) wide, and 21.3 m (70 ft) long. The next day, February 6, Beale noted, "[We] came to Walnut Creek, where we stopped for breakfast. Water not so plentiful as when we passed here outward bound."

Beale travelled eastward at this point and the next day reached the Little Colorado River. It seems unlikely that he traveled upstream a distance of about 19.3 km (12 mi) to the center of WACA, but rather continued down toward the Little Colorado River. A map accompanying his report does not indicate that he backtracked or deviated from the west to east path. Therefore, little evidence supports statements that Beale visited WACA during his 1857-58 journey.

These references indicate the possibility of at least seasonal water in Walnut Creek, but no evidence of perennial water. This conjecture is supported in a report by R. T. Cross (1884). She visited Walnut Canyon during midsummer of 1884 and stated, "Trails, of

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[2] Whipple called the caves Cosnino Caves after the Hopi name for the Havasupai Indians. The site was later (c. 1873) called Coconino Caves by Capt. G. M. Wheeler (Barnes 1935) and today is known as Turkey Tank Caves. The caves and associated permanent water hole known as Turkey Tanks are located outside WACA in T. 22 N., R. 9 E., Sec. 35, on the San Francisco Wash, north of Winona (Colton 1946).

which there is now no trace, led down to the large, clear pools of water which abound in the canon at this season of the year." The fourth pre-Lake Mary reference (Schuyler 1909) described Walnut Creek as an intermittent stream only flowing when there is sufficient rain or snowmelt.

A possible fifth pre-Lake Mary reference comes from taped conversations with 2 long-term residents of the Flagstaff area, Fred Metz and Fletcher Fairchild. Unfortunately, neither interview referenced the dates about which the statements were made, but both residents were born at the turn of the century. Metz (pers. com., 1974) recalled that he was "down there in the summer when there was a great deal of water running through there very swiftly." He stated that the water was "maybe twelve to eighteen inches deep." Fairchild (pers. com., 1974) recalled that, "There was always water in the bottom. I don't know about today whether there is or not." He further stated that, "Well I don't think it was particularly a stream. Seems to me like it just kind of formed down in the bottom there, kind of like a basin. We never considered it a stream, course in flood times, it would fill and probably overflow. It sort of ran down Walnut Canyon, where it's, far as Fisher Tank that I know of and I don't know what became of it from there—just deteriorated into the soil I presume [Note: Fisher Tank is located upstream of WACA, near Fisher Point]." When asked if the runoff was from the canyon itself or from Lake Mary, Fletcher added, "I think it was just runoff more or less." He felt that there had been a climate change around Flagstaff with more moisture in the past. When queried about fish of any kind in Walnut Creek, Fletcher noted, "Not up in that area until they stocked Lake Mary; that was the old Lower Lake Mary, there was no upper Lake Mary [Note: Upper Lake Mary was built 1940-41]. It was just pools and so forth during the high water in the spring. Runoff and then from Old Lake Mary on south toward Mormon Lake there'd just be these pools and then they would usually dry up by fall when the rain was starting. Course the summer rain would help them some. That was a very poor summer rain in those days; in fact the Old Lake Mary used to be full of sink holes and it didn't hold water very good. However it was a pretty good sized lake."

In 1885-1886 Santa Fe Dam was built on Walnut Creek. The dam is presently located 40 m (131.3 ft) downstream of the eastern boundary of WACA. Santa Fe Dam was built by the Santa Fe Railway to impound water for steam locomotives.[3] The dam filled by March 8, 1898, and if watertight would have supplied the Santa Fe Railway 277,100 litre (60,000 gal) daily for over 2 years, with a daily evaporation of 0.9 cm (0.03 ft). Yet, 196 days later, on September 20, the water disappeared. Significantly, no runoff in 1899

[3] To build the dam, builders had to excavate 8.5 m (28 ft) to reach bedrock. The dam had the following dimensions: 9.1 m (30 ft) at bedrock, 36.6 m (120 ft) at streambed, 81.7 m (268 ft) at top of dam, 23.6 m (77.6 ft) at extreme height, 18.7 m (61.5 ft) at base; top was 3.9 m (13 ft) in width and 3.2 m (10.4 ft) below the crest (Arizona Daily Sun 1905).

refilled the dam.[4] This historical review provides some evidence of the intermittent nature of Walnut Creek.

The lack of water available to refill Santa Fe Dam in 1899 is indicated by the following report of a "long drought" that prevailed in Arizona from 1896 to 1904. "The scarcity of water during those years forced many stockman out of business and cattle and sheep were rounded-up on the dusty site of Mormon Lake. Rogers Lake, Marshal Lake and most of the springs of the San Francisco Plateau dried up and failed entirely during some of these years, particularly during 1897 and 1898" (Northern Arizona Leader 1970).

T. A. Riordan, president of the Arizona Lumber and Timber Company, realized the scarcity of water in the Flagstaff area and desired to build a reservoir. Water shortages were severe for early Flagstaff, with too much water in the spring and not enough in the summer. Some years were wet, while others where bone dry (Smith 1983). Riordan bought out a homesteader in Clark valley for $2,600 (John Clark, the homesteader after whom the valley was named) and settled in the valley from 1877 to 1883 (Barnes 1935). In the fall of 1903, T. A. Riordan built a small test dam across the lower end of Clark Valley to see if it would be possible to capture water that otherwise flowed seasonally into Walnut Canyon (LaBonne 1981). That winter the snowmelt filled the reservoir and water remained after the spring thaws. Riordin's attorney, E. E. Eillinwood, requested the U.S. Department of the Interior to give the company permission to install a permanent dam (Smith 1983). Land was specifically set aside under federal statutes, with the stipulation that the area would never be fenced or closed to public use. Water reached a certain level, but no higher. Apparently the water reached a crack in the volcanic flows (called the ice caves) and poured down the fissure. Construction of the permanent dam began in 1904 and was completed in 1905. The ice caves were filled with rock, cement, and sand, and the reservoir was able to impound more water. The dam, with a length of 308.9 m (1,014 ft), width of 228.8 m (751 ft), height of 11.6 m (38 ft) impounded a reservoir with a capacity of 15,142,017,405 litre (4,000,533,000 gal). The reservoir was named Lake Mary after Riordan's eldest daughter (Arizona Daily Star 1944).

Walnut Creek is described as having only seasonal flows in the first reference located after the building of the Lake Mary Dam (Shimer and Shimer 1910):

> This canyon empties its waters into the Little Colorado River to the northeast, but during the dry season water remains only in scattered basins, yet is comparatively good for drinking.

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[4] A rail line was put in from Winona to carry water to the main line, but the track was abandoned and removed in 1897 when a pipe line was put in. Water traveled by gravity flow to storage tanks at Angel, near Winona. The Santa Fe Railway Co. abandoned use of the reservoir in 1904 (Arizona Heritage 1979). In 1934 or 1939, stockmen from the Kellum Ranch dynamited the dam near the north end, loosening masonry to allow water to leak out downstream for stock, even at low reservoir level (Arizona Heritage 1979; Arizona Daily Sun 1905).

A slightly later reference by H. S. Colton, founder of the Museum of Northern Arizona and author of numerous articles on WACA, emphasized the seasonality of Walnut Creek flows and blamed Lake Mary Dam for reducing flows into WACA (Colton 1929, 1932):

> The trail [in Walnut Canyon] to water led down to the right of the entry trail to a pool in the canyon. Since the Lake Mary dam was constructed across Walnut Creek, little water reaches the canyon to fill its pools, even when no water is visible at the surface, water may be obtained by digging in the sand. . . Walnut Creek, which eroded the canyon, is an intermittent stream so typical of the semi-arid Southwest. For a few weeks, when snows are melting in an extensive basin south of Flagstaff, Walnut Creek is a rushing stream, the rest of the year it is dry. After flowing north through open valleys until within a few miles of Flagstaff, the stream suddenly turns east and for fifty miles zig-zags through a series of limestone and lava canyons until its waters meet the Little Colorado.

Katherine Bartlett, who was an associate of Harold S. Colton, accompanied him on a canoe trip in the late 1930s. She recalled that the party floated runoff from Walnut Canyon on the San Francisco Wash drainage from Winona to just above the junction of the Rio de Flag (K. Bartlett, pers. com., 1985). Presumably, water spilled over the Santa Fe Dam and was sufficient for canoeing.

In 1940-41, Flagstaff increased its water reservoir system with the completion of Upper Lake Mary (Flagstaff Water Department 1941; Miller 1954). Work on the dam at the upper end of Lake Mary was started November 5, 1940, and completed July 30, 1941. The reservoir increased Flagstaff's reserve storage to 15 billion litre (4 billion gal).

The dam at Upper Lake Mary was raised 3.8 m (12.5 ft) in 1951, thus increasing the total capacity to greater than 19 billion litre (5 billion gal) (Miller 1954).

Previous to the alteration of the Upper Lake Mary Dam, King (1941) stated, "Before the construction upstream of the modern dam which formed Lake Mary, Walnut Creek was a perennial stream which undoubtedly provided sufficient water for the needs of the cliff dwellers."

Flows out of Lake Mary have, however, been documented. After a pool survey Ellis (1973) stated that Lake Mary overflowed in April due to the 325 cm (128 in.) of snow that fell in 1972-73 with an additional 12.7 cm (5 in.) of moisture in March. Upper Lake Mary overflowed on April 12, and Lower Lake Mary overflowed on April 17. Flagstaff city engineers estimated a flow of 1,277,438 to 1,447,763 litre (337,500 to 382,500 gal) per min. Flow was estimated by Vic Vieira on 14 May 1973 at 1.12 m^3 per second (cms) (40 ft^3 per second [cfs]) or 68,130 litre/min (18,000 gal/min). Such flows are episodic, however, and decrease rapidly. One week later, flow was estimated at 0.2 cms (6.4 cfs) or 68,130 litre/min (2,880 gal/min). No flow was visible by May 26, 1973.

DISCUSSION

This chronological review of the history of water flows in Walnut Creek substantiates the current, seasonal existence of the Creek. Stream flow may have been perennial in the distant past, but in the last 100 years, water has flowed only during rain and snowmelt events.

The intermittent nature of the Walnut Canyon drainage is reflected in the precipitation records. Although the Flagstaff area received a mean annual precipitation of 51.49 cm (20.27 in.) from 1899 to 1951 (Green and Sellers 1964) and 50.29 cm (19.80 in.) from 1950 to 1970 (Sellers and Hill 1974), most of the precipitation occurred early July through early September. Currently, up to 19.05 cm (7.5 in.) falls from afternoon thunderstorms during "monsoon" months. During and after such storms Walnut Creek is likely to flow. Winter precipitation in the form of snow tends to be less consistent, with an average annual snowfall of 147.32 cm (58 in.), but an excess amount may accumulate during severe winters. Snowmelt resulting from severe winters is also likely to contribute to stream flow.

Much of the runoff from rainfall and snowmelt is likely to be lost due to the nature of the geology and hydrology of the WACA area. The San Francisco Plateau, of which WACA is a part, is characterized by relatively large amounts of precipitation and small amounts of surface water runoff. Precipitation either infiltrates surficial deposits, joins ephemeral stream flow and/or lake storage, or enters the groundwater system as recharge through fractures and solution openings. Ephemeral streams in the Lake Mary area include Newman Canyon, Elk Meadows, Howard Draw, Priest Draw, Skunk Canyon, Fay Canyon, as well as Walnut Canyon (Harshbarger et al. 1977). Extensive fracturing near faults in the Coconino Sandstone increases the permeability of the aquifer (Koval 1976). Groundwater in the Lake Mary area flows laterally in the Coconino-Supai aquifer via the Lake Mary graben and under Anderson Mesa in a northeasterly and easterly direction. It then drops to the Supai-Redwall-Martin aquifer and discharges chiefly as springs from the solution cavern system in the lower 20.9 km (13 mi) of the Little Colorado River (Harshbarger et al. 1977). Such geologic and hydrologic influences greatly preclude Walnut Creek from being a perennial stream even under seasonal precipitation regimes.

Evidence from fishery records further indicates that Walnut Creek only provides seasonal waters. Walnut Creek is neither listed as a perennial stream nor have fish been collected from it (Silvey et al. 1984). Unofficial reports of fish in the canyon may stem from stocked fish from the Lakes Mary that were flushed downstream during overflows and remained in scattered pools. Presumably, a perennial stream would provide stable fish habitat and support populations of fish species.

To summarize, since the 1850s Walnut Creek has been an intermittent stream typical of the semi-arid Southwest. Prior to 1905, water from snowmelt and summer thunderstorms flowed down Walnut Canyon for a few weeks each year. Measurable amounts of water

entered Walnut Canyon over Lower Lake Mary dam in wet years. However, the total amount probably declined after the completion of Upper Lake Mary in 1941. Today, water flows through the canyon when the reservoirs overflow. Otherwise, moisture found in the drainage and in scattered basins and pools within the monument boundaries results from runoff from the steep canyon walls.

REPHOTOGRAPHY OF HISTORICAL PHOTOGRAPHS

METHODS

Vegetation change along the riparian zone of Walnut Canyon within the WACA boundaries was studied by comparing photographs from the past with those taken in August 1985 at the same sites. Historic photographs were obtained at WACA's photo archive library and at the Special Collections Library, NAU. The majority of historical photographs of WACA show archeological remains rather than the canyon bottom. However, 19 historic photographs show aspects of the canyon bottom. Eight photographs could not be matched. Two appeared to have been taken at locations outside the WACA boundaries, while 6 could not be matched due to the absence of recognizable features and photo information. Eleven matched pairs are presented in this report; their locations are indicated in Figure 2.

The older pictures were reprinted to a 5- X 7-in. format by the Public Information Office at NAU. Copies of all prints and negatives may be viewed at the Special Collections Library, NAU. A hand held Olympus AFL quick flash camera (35 mm autofocus lens) with Kodak Plus-X pan black and white film (ISO 125) was used by the author for recent photographs of the same sites.

The duplicated photographs are not exact replicas of the original photographs. Although an effort was made to locate the "vantage point" or exact location of the original photographer's camera, time restraints and amateur photography introduced several factors. In all photographs, the focal length of the lens may be different. However, it is not necessary to match the focal length as long as the vantage point is replicated. More importantly, the position of the camera has 3 interrelated functions: inclination (camera pointing up or down), rotation (clockwise or counterclockwise revolution of the camera body), and azimuth (compass direction). Because the author's camera was hand held, the 3 functions found in the original photo were not replicated. Also, lighting (time of day) and seasonal (time of year) differences were introduced that may influence photographic interpretation. However, the rephotographs are sufficiently similar for comparison.

RESULTS

In the following plates, the historical photograph is labeled "a," and the matched photograph "b." Photographs taken within the same general area are grouped for reference. Original photos and negatives are cited by collection numbers. Photos from the Special Collections Library are listed by either an NAU number or a Northern Arizona Pioneer Historical Society (NAPHS) number. A few of the NAU and NAPHS photos are also cited by the collector who donated the photos. The WACA photos are cited by a WACA negative number (neg. no.) and a classification number. A discussion of changes in vegetation accompanies each photo pair. Common and scientific names follow Lehr (1978).

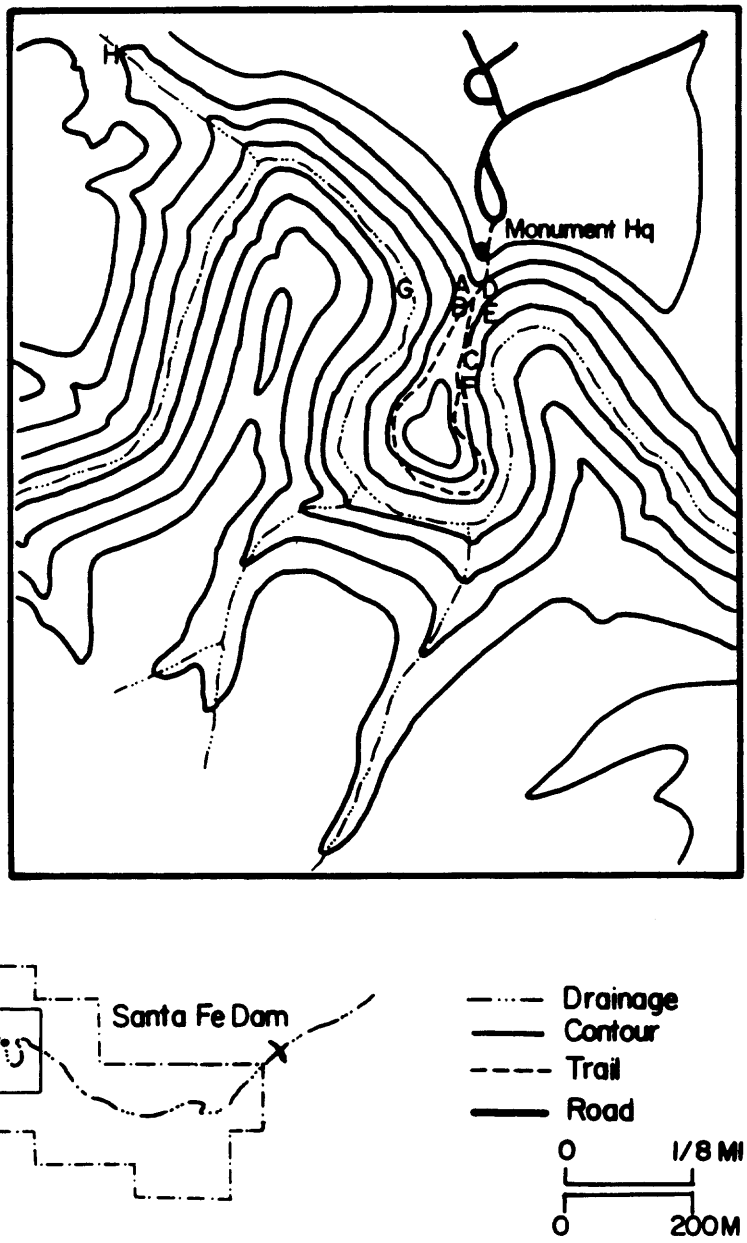

Figure 2. Approximate location of vantage points of historical and recent photograph pairs within Walnut Canyon National Monument, Arizona: Figure 3 at "A"; Figures 4-5 at "B"; Figure 6 at "C"; Figures 7-8 at "D"; Figure 9 at "E"; Figure 10 at "F"; Figure 11 at "G"; Figure 12 at "H." The vantage point of Figure 13 is near the Santa Fe Dam as shown on the location map above.

DISCUSSION

Eleven matched photographs are presented in this report. Three photos (Figs. 3a, 4a, 12a, and 13a) predate construction of Upper Lake Mary Dam; 2 photos (Figs. 4a and 9a) were taken during 1941, the year Upper Lake Mary Dam was built; and the remaining 6 historical photos postdate the construction of Upper Lake Mary Dam. The following conclusions can be drawn from the rephotographic survey:

1. The earliest date water flow in Walnut Canyon can be documented is in the circa 1900 postcard photo (not shown). Water is shown in 1939 (Fig. 13a), 1941 (Fig. 9a), and 1949 (Fig. 11a). Flowing water is evident in the 1949 photo.

2. Riparian vegetation in Walnut Canyon has increased dramatically since 1949 (Fig. 11). Today, an impenetrable jungle of New Mexican locust (*Robinia neomexicana*), box elder (*Acer negundo*), Arizona walnut, and Gambel oak (*Quercus gambelii*) chokes the canyon bottom. Apparently, historical flows and the resultant riverine scouring maintained an open, nonvegetated river bed prior to the 1950s. In the past three decades, riparian vegetation has become established. Mature vegetation is able to withstand and survive high flows such as the 21-24 cms (750-850 cfs) flow in 1973 (Walnut Canyon National Monument 1976). Flow does not last long enough to kill plants along the canyon floor by inundation and submergence.

3. North-facing slope vegetation cover may have increased since the turn of the century. An increase in such cover is noticeable when comparing the photo from 1906 with the recent photo (Fig. 12). This conclusion must be regarded carefully, however, because of the limited number of photo points and the difficulty of interpreting the sparsity of vegetation in Figure 12a. Little appreciable change has occurred since 1974 (Figs. 5, 6, 8, and 10).

4. Vegetation on east- and south-facing slopes has changed little since the turn of the century. Plants can easily be matched when comparing recent photos with those from 1941 (Fig. 4), and 1974 (Figs. 6 and 10).

The north-facing slope (left) of Figure 3a has become overgrown with vegetation. Tree and shrub canopies have thus made the slope and ruins less visible. However, the south-facing slope (right) of Figure 3a has changed little. The open stream channel and boulders apparent in the historic photo are no longer visible in Figure 3b, as the riparian vegetation has become firmly established. Today, travel along the stream bottom is difficult owing to the jungle-like growth of New Mexican locust (*Robinia neomexicana*), Gambel oak (*Quercus gambelii*), box elder (*Acer negundo*), and Arizona walnut (*Juglans major*) saplings and trees. An earlier photograph (not shown; by J. A. Mauer in 1897; WACA photo, no negative number) shows a similar view and documents a similar vegetation pattern. Apparently, overflow from Lower Lake Mary Dam was sufficient to scour and maintain the open stream channel. Little growth of riparian vegetation is visible. Sixty-two years have elapsed since Figure 3a was taken in 1923. Recent vegetation change is dramatic; the stream channel in Figure 3b is choked with vegetation.

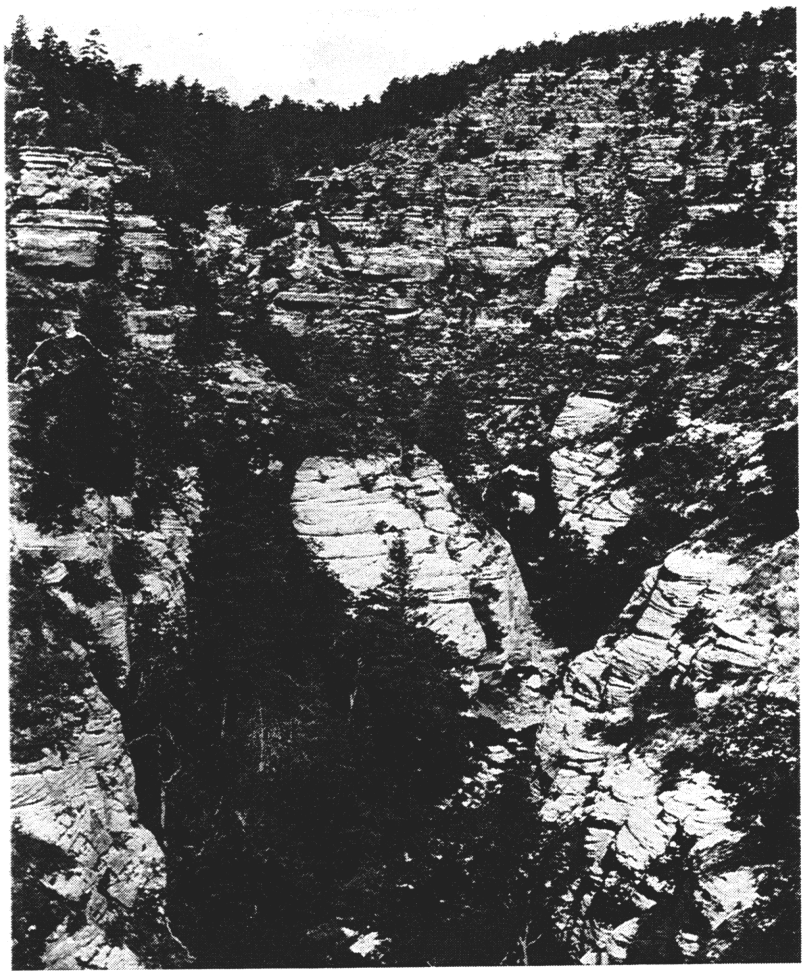

Figure 3a. "Looking up canyon, side canyon coming in from ranger quarters shown in background [indicated by arrow]," Photographer unknown, taken ca. 1923, Walnut Canyon National Monument, Arizona. WACA Neg. 1875, Classification No. 719.

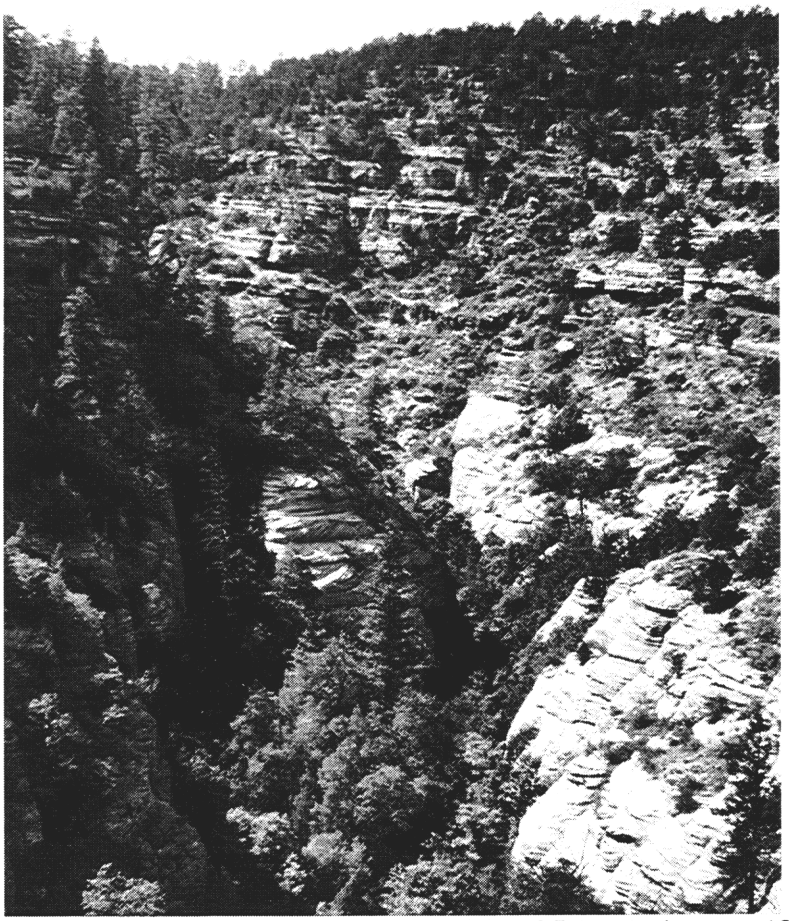

Figure 3b. Looking upstream and west from saddle of Island, August 1985, Walnut Canyon National Monument, Arizona.

Paul Beaubien, an archaeologist who became the first custodian of Walnut Canyon National Monument, took Figure 4a in 1941. Water can be seen flowing downstream (toward top of photo) with a little "white water" indicating turbulence and flow. By 1966 the stream bottom had developed riparian thickets (N. Ritchie photograph, not shown; WACA Neg. 66-C-5, Classification No. 551.43). The view of the canyon bottom today is choked by vegetation (Fig. 4b). However, the vegetation on the east-facing slope to the right and center of the photograph has changed little. The same tree and shrub individuals can easily be matched from 1941 to 1985.

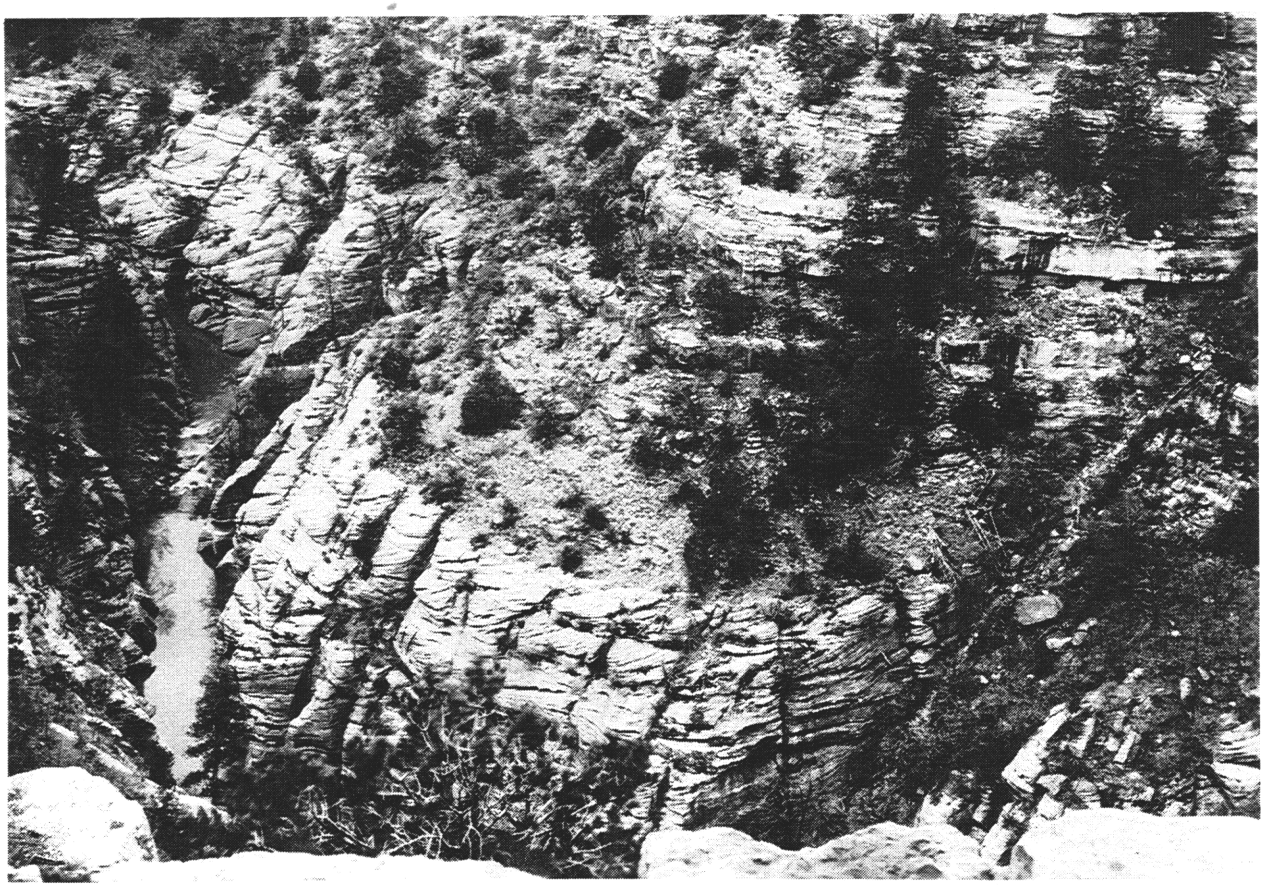

Figure 4a. "View into Walnut Canyon showing running water in canyon bottom and contact between Kaibaba Limestone and Coconino Sandstone, several under-ledge ruins visible," Paul Beaubien photographer, May 1941, Walnut Canyon National Monument, Arizona. WACA Neg. 6409.

Figure 4b. Looking downstream and south from visitor center (Island to left), August 1985, Walnut Canyon National Monument, Arizona.

Only 11 years have elapsed since the original photograph (Fig. 5a) was taken in 1974, and little vegetation change has occurred. Tree and shrub individuals can easily be matched between the photos.

Figure 5a. View of north-facing slope of canyon above riparian zone, Walnut Canyon National Monument, Arizona. No locality information, 1974, Paul Switzer Collection, 1974, NAU 426-605-6, Special Collections Library, Northern Arizona University.

Figure 5b. View across canyon to south rim opposite visitor center (Island to left), August 1985, Walnut Canyon National Monument, Arizona.

Eleven years have elapsed since the original photo (Fig. 6a) was taken in 1974. Little change is visible between Figures 6a and 6b, and shrubs can easily be matched. The riparian vegetation at bottom right is similar.

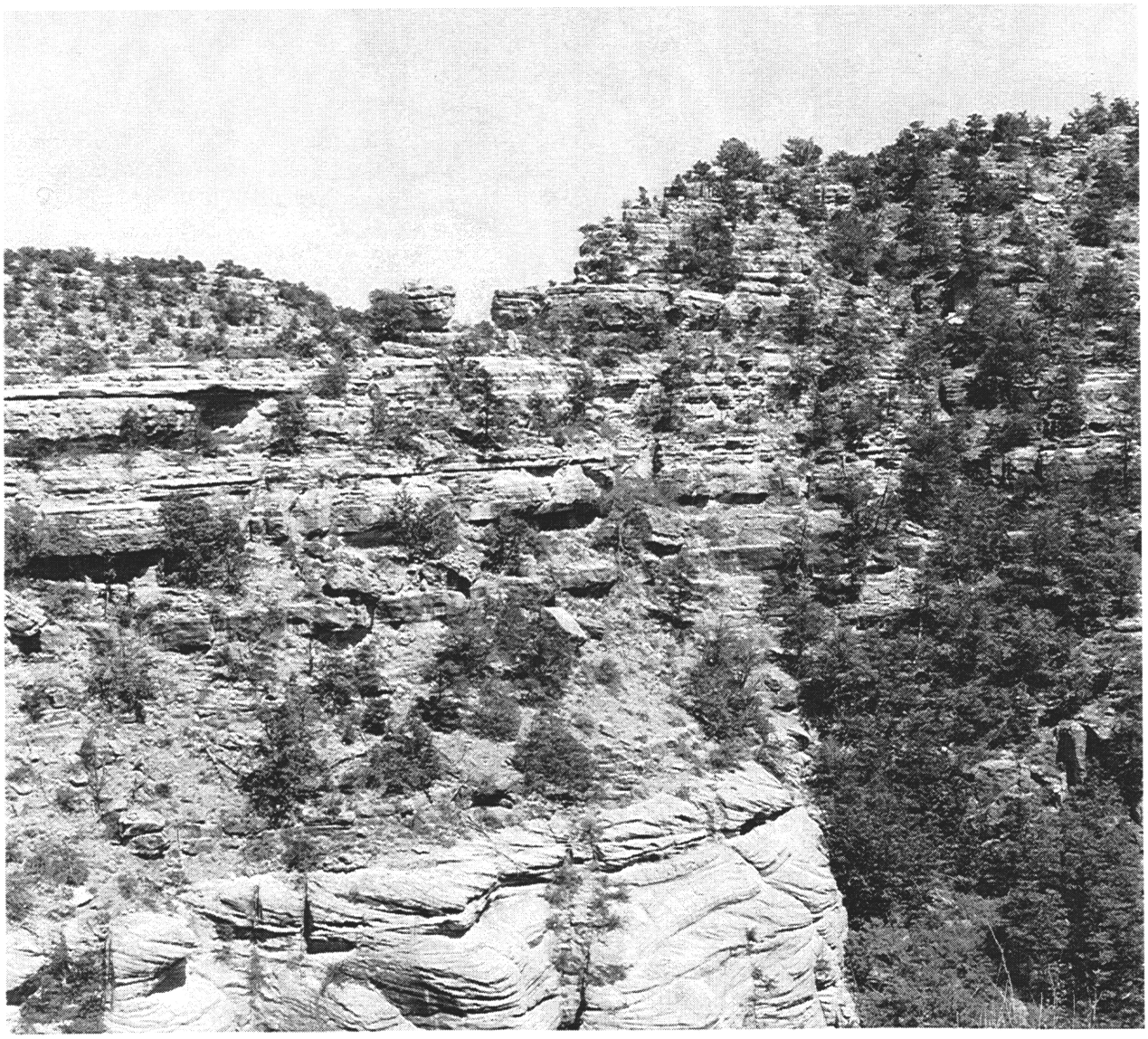

Figure 6a. View of southwest-facing slope opposite Island, 1974, Walnut Canyon National Monument, Arizona. No locality information, Paul Switzer Collection, 1974, NAU 426-606-11, Special Collections Library, Northern Arizona University.

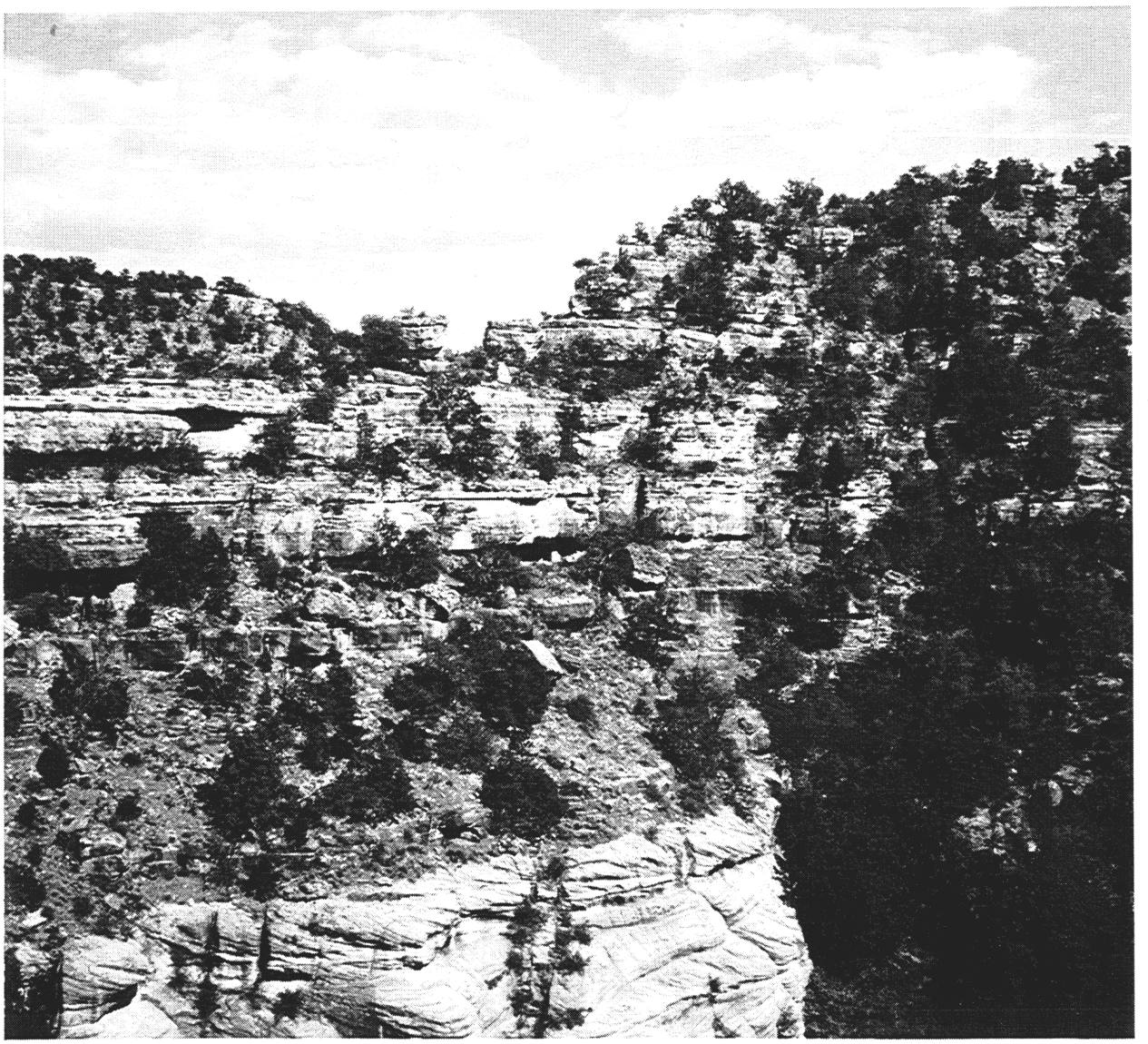

Figure 6b. View east from Island across canyon to south rim, August 1985, Walnut Canyon National Monument, Arizona.

This photo pair is somewhat difficult to compare because the 1964 photo (Fig. 7a) was printed backwards. Use boulders in Figure 7a (far right) as orientation; they are located at far left in Figure 7b. A few standing dead snags are visible in both photos; however, the riparian vegetation has grown extensively in the intervening 21 years. The canyon bottom appears more lush in Figure 7b with the canopy cover filling the stream channel from bank to bank.

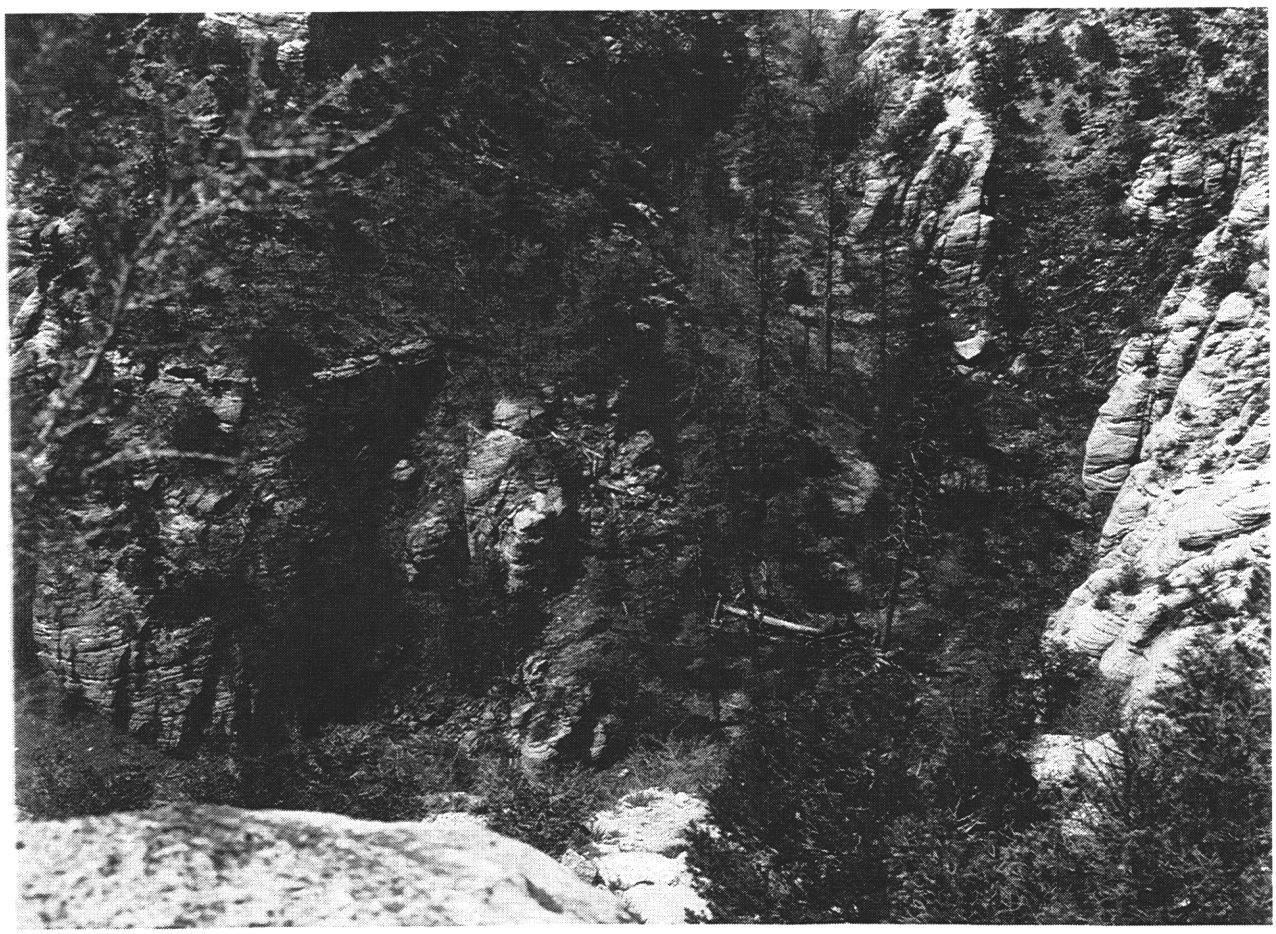

Figure 7a. "Tree fall in canyon from #2 to east, N. Ritchie photographer, April 25, 1964," Walnut Canyon National Monument, Arizona. WACA Neg. 64-38.

Figure 7b. View east (down-canyon) from trail leading to Island saddle, August 1985, Walnut Canyon National Monument. Note: Figure 7a is printed backwards (location is as in Figure 7b), and #2 does not refer to the Second Fort.

Figure 8 is similar to Figure 7, with the view to the east and up-canyon. Eleven years have elapsed since the original photo (Fig. 8a) was taken in 1974. Two obvious standing dead snags are visible in both photos. Vegetation on the canyon slopes has not changed appreciably.

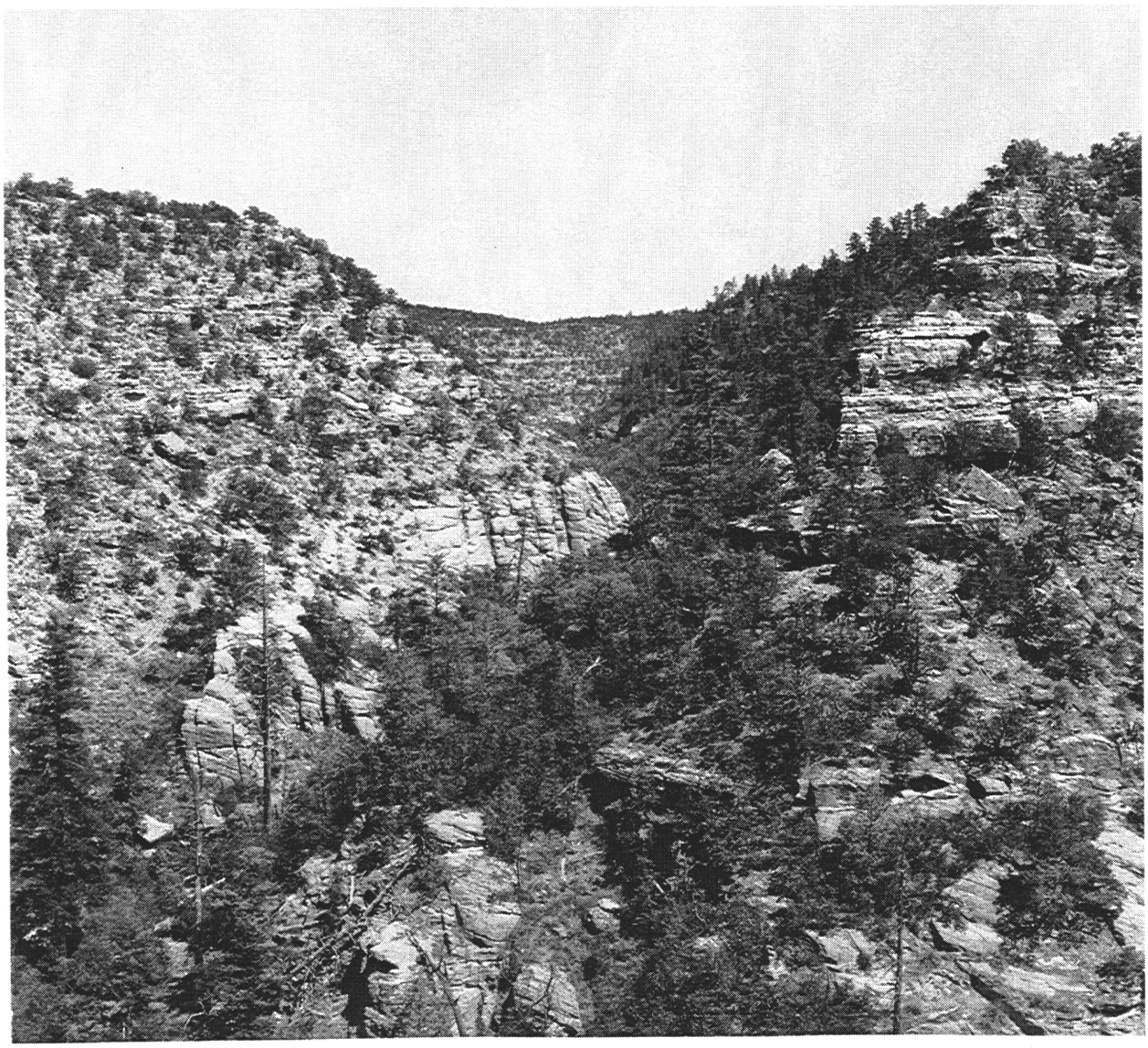

Figure 8a. Looking up-canyon, 1974, Walnut Canyon National Monument, Arizona. No locality information, Paul Switzer Collection, 1974, NAU 426-606-12, Special Collections Library, Northern Arizona University.

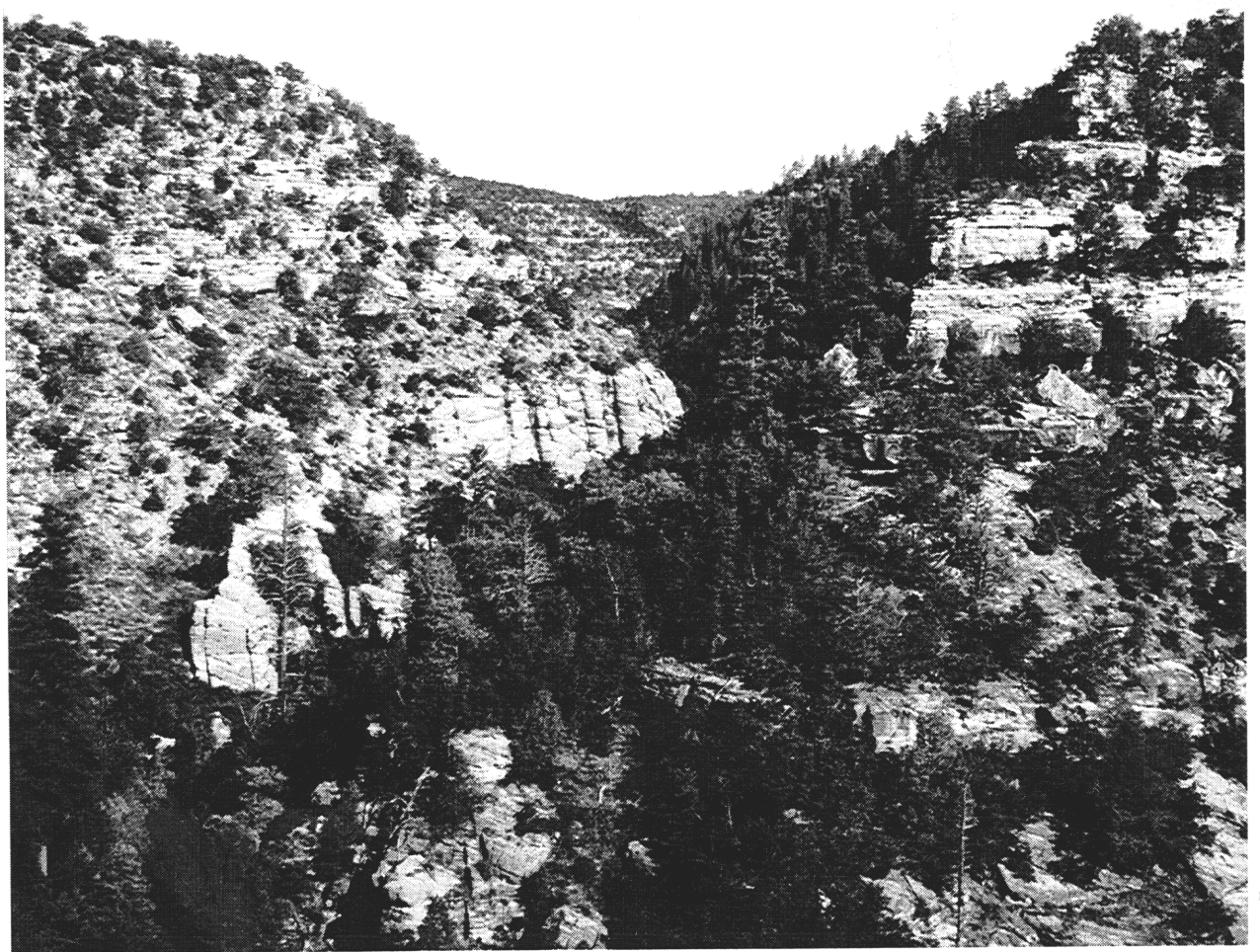

Figure 8b. Looking east, up-canyon from saddle of Island, August 1985, Walnut Canyon National Monument, Arizona.

Figure 9a shows water apparently pooled in Walnut Canyon in 1941. Presumably, the water had overflowed the Upper and Lower Lake Mary dams. In 1941, Flagstaff received 63.55 cm (25.02 in.) of precipitation. The previous year 53.89 cm (21.22 in.) were recorded (Green and Sellers 1964). Both years exceeded the 1899-1951 mean precipitation of 51.49 cm (20.27 in.). Consequently, Walnut Creek should have had a good opportunity to receive overflow water from the reservoirs. No flow over the rocks in the center of the channel is apparent. Consequently, the water in Figure 9a appears to be pooled. Possibly, the Santa Fe Dam had pooled the flow and created a reservoir backed up to and upstream of the Island. The recent photo (Fig. 9b) exhibits the amount of vegetation that has grown in the intervening 44 years. Some open area is, however, still visible. One may walk this section of the canyon bottom without encountering the jungle-like growth found just upstream.

Two other photographs (not shown) of similar location, taken by Paul Beaubien in 1941, also show water in Walnut Canyon (WACA Neg. 6410, Classification No. 551.48; WACA Neg. 6593, Classification No. 551.57).

Figure 9a. "Walnut Canyon with water in stream," Paul Beaubien photographer, 1941, Walnut Canyon National Monument, Arizona. WACA Neg. 6595, Classification No. 551.57.

Figure 9b. Looking south on eastern side of Island from trail leading to Island saddle, August 1985, Walnut Canyon National Monument, Arizona.

Only 11 years have elapsed since the original photo (Fig. 10a) was taken in 1974. Little vegetation change is apparent and snags, trees, and shrubs can easily be matched.

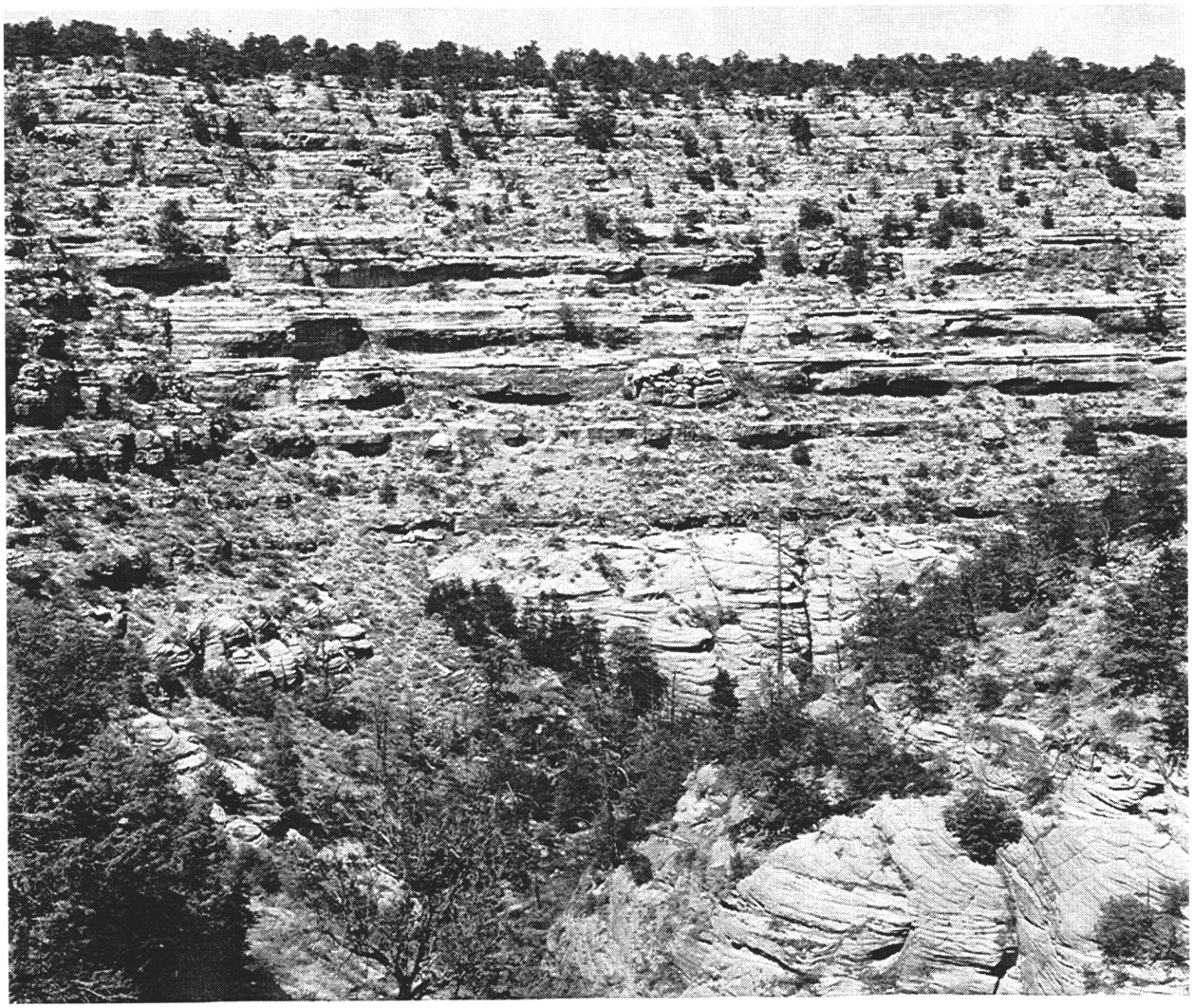

Figure 10a. View of south-facing slope east of Island, 1974, Walnut Canyon National Monument, Arizona. No locality information, Paul Switzer Collection, 1974, NAU 426-606-8, Special Collections Library, Northern Arizona University.

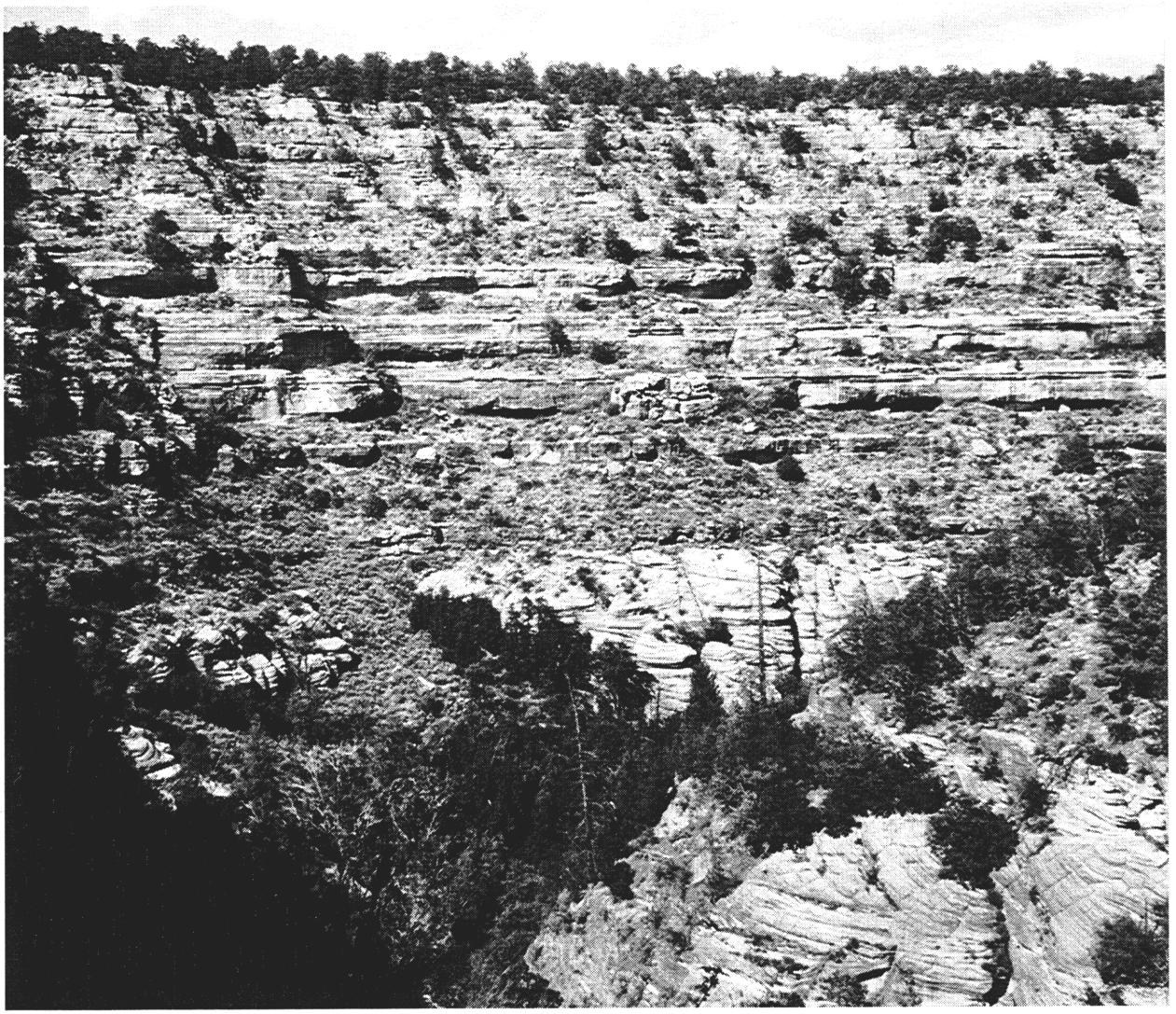

Figure 10b. View north from eastern edge of Island trail (visitor center to left), August 1985, Walnut Canyon National Monument, Arizona.

Thirty-six years have elapsed between the photo taken in 1949 (Fig. 11a) and the recent photo (Fig. 11b). Water can be seen flowing over and downstream (toward bottom of photo) in Figure 11a and spring leaves have yet to appear. Apparently, there is sufficient flow from Upper and Lower Lake Mary reservoirs for a stream to flow down Walnut Canyon. In 1949, the Flagstaff area received 67.28 cm (26.49 in.) of precipitation, 15.24 cm (6 in.) over the mean for the 1899-1951 period (Green and Sellers 1964). The title of the photo may be in error as water "caused by rare surplus of water in Santa Fe Dam" would be pooled, not flowing. Undoubtedly the water did pool behind the Santa Fe Dam, but at this point the stream still flows. The canyon bottom has been scoured of vegetation and is open. The recent photo shows the dramatic growth of riparian vegetation. The canyon bottom is choked with the jungle-like growth of New Mexican locust (*Robinia neomexicana*), box elder (*Acer negundo*), Arizona walnut (*Juglans major*), and assorted sub-shrubs, herbs, and grasses.

Another Homer Hastings photograph (not shown) of same date and similar location illustrates the same situation (WACA Neg. 6171, Classification No. 551.43).

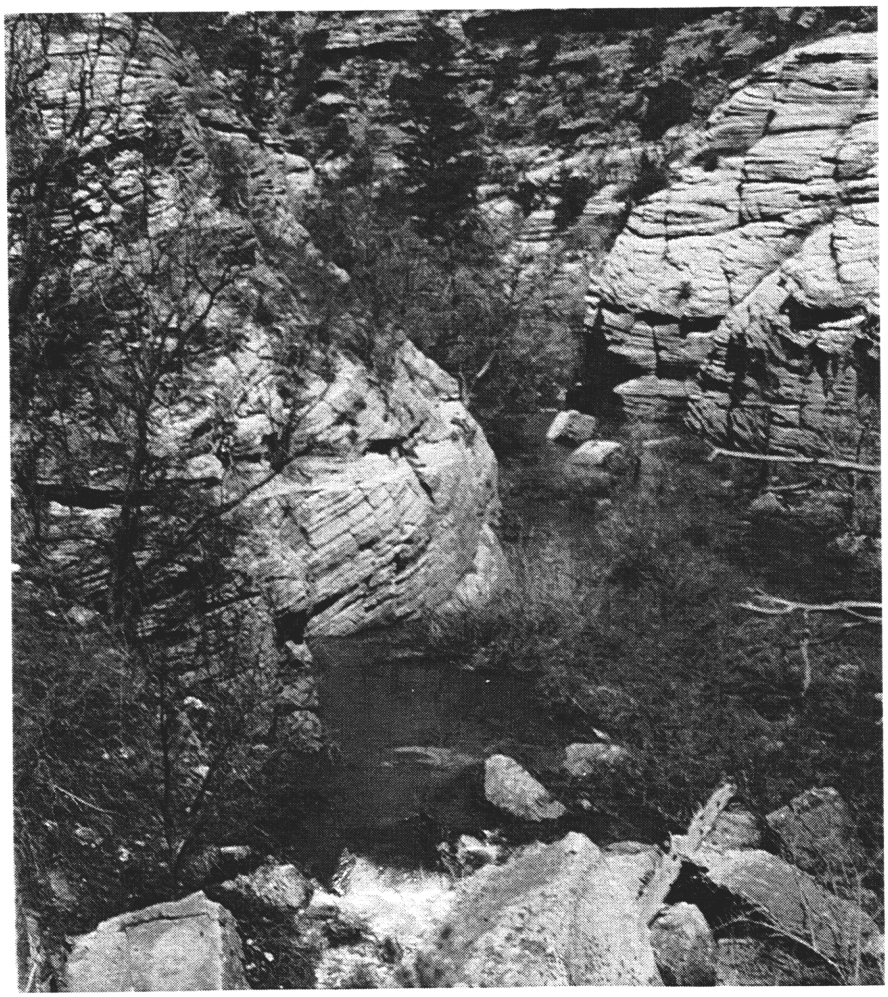

Figure 11a. "Water in Walnut Canyon caused by rare surplus of water in Santa Fe Dam, from west of Island looking upstream," Homer Hastings photographer, April 22, 1949, Walnut Canyon National Monument, Arizona. WACA Neg. 6170, Classification No. 551.43.

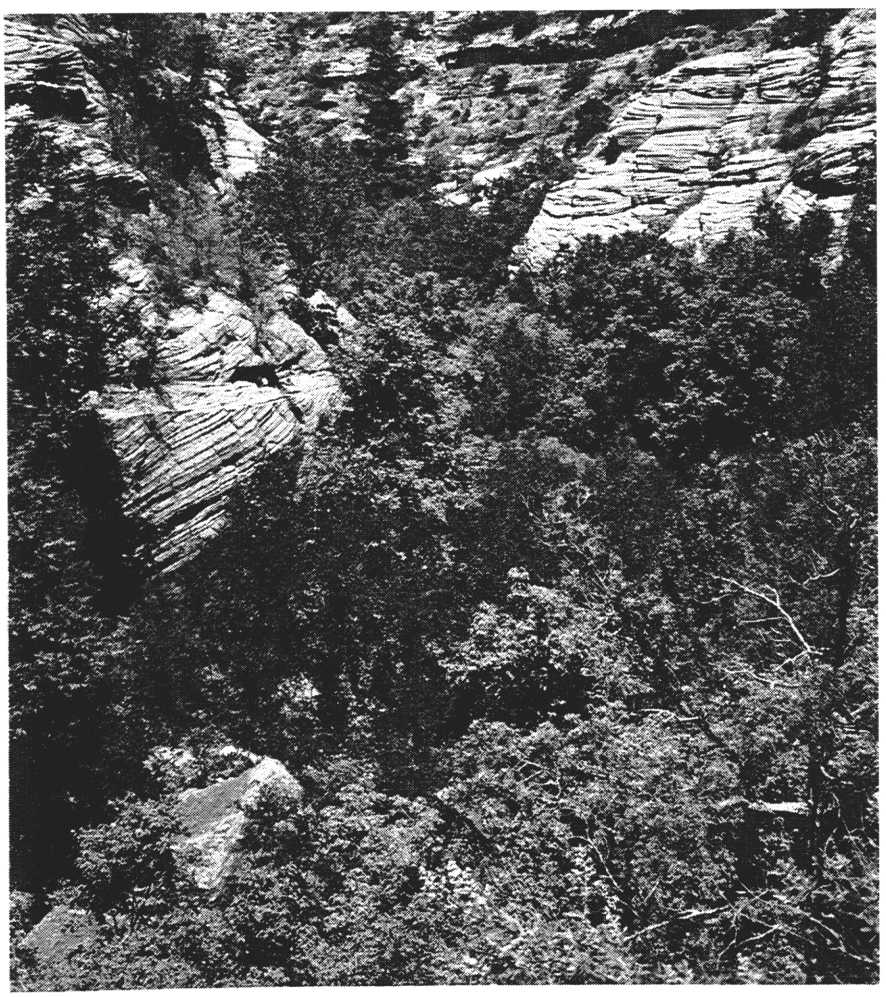

Figure 11b. Looking upstream and northwest from near canyon bottom off old trail to water (Kokopelli Fault Trail), August 1985, Walnut Canyon National Monument, Arizona.

Figure 12 shows a view of the ridge line on the Island from the abandoned trail below the old ranger cabin to the west of the visitor center. A circa 1900 postcard (not shown) of Walnut Canyon indicates some water present in the drainage (George Hochderffer Collection, NAPHS 321145, Special Collections Library, Northern Arizona University). Seventy-nine years have elapsed between Figure 12a and Figure 12b. Vegetation change is readily apparent for the northwest-facing slope at the right of each photo. The 1906 photo shows an almost denuded northwest-facing slope with much of the rocky area visible. The lack of vegetative cover on this slope may have resulted from wildfire. The recent photo shows the slope covered with evergreen trees and other small trees and shrubs. Trees and shrubs on the south-facing slope (left) can be matched. The canyon bottom is choked with riparian vegetation.

Figure 12a. "Canyon and ruins, looking southeast [downstream] from visitor center near saddle of Island Trail," Henry G. Peabody photographer, April 1906, Walnut Canyon National Monument, Arizona. WACA Neg. 12,324, Classification No. 571.84.

Figure 12b. Looking east at Island from abandoned trail below old ranger cabin, August 1985, Walnut Canyon National Monument, Arizona.

Figure 13 shows a meander in Walnut Canyon about 0.4 km (0.25 mi) above Santa Fe Dam in 1939. The "lake" or reservoir held water that presumably overflowed the Lower Lake Mary Dam. (The dam for Upper Lake Mary had not yet been built). The Flagstaff area received 52.27 cm (20.58 in.) of precipitation in 1938 and less than 10.16 cm (4 in.) for the first 4 months of 1939 (Green and Sellers 1964), an amount typical for the 1899-1951 period. The deciduous trees—Arizona walnut (*Juglans major*), Gambel oak (*Quercus gambelii*) and box elder (*Acer negundo*)—at the shoreline have not leafed out in the 1939 photo, but can be seen in the same locations in the recent photo. Today, the dry reservoir bed or canyon bottom is filled with an almost pure stand of common sunflower (*Helianthus annuus*), a plant that thrives in disturbed, deep, sandy soils. Little vegetation change is apparent on the canyon slopes.

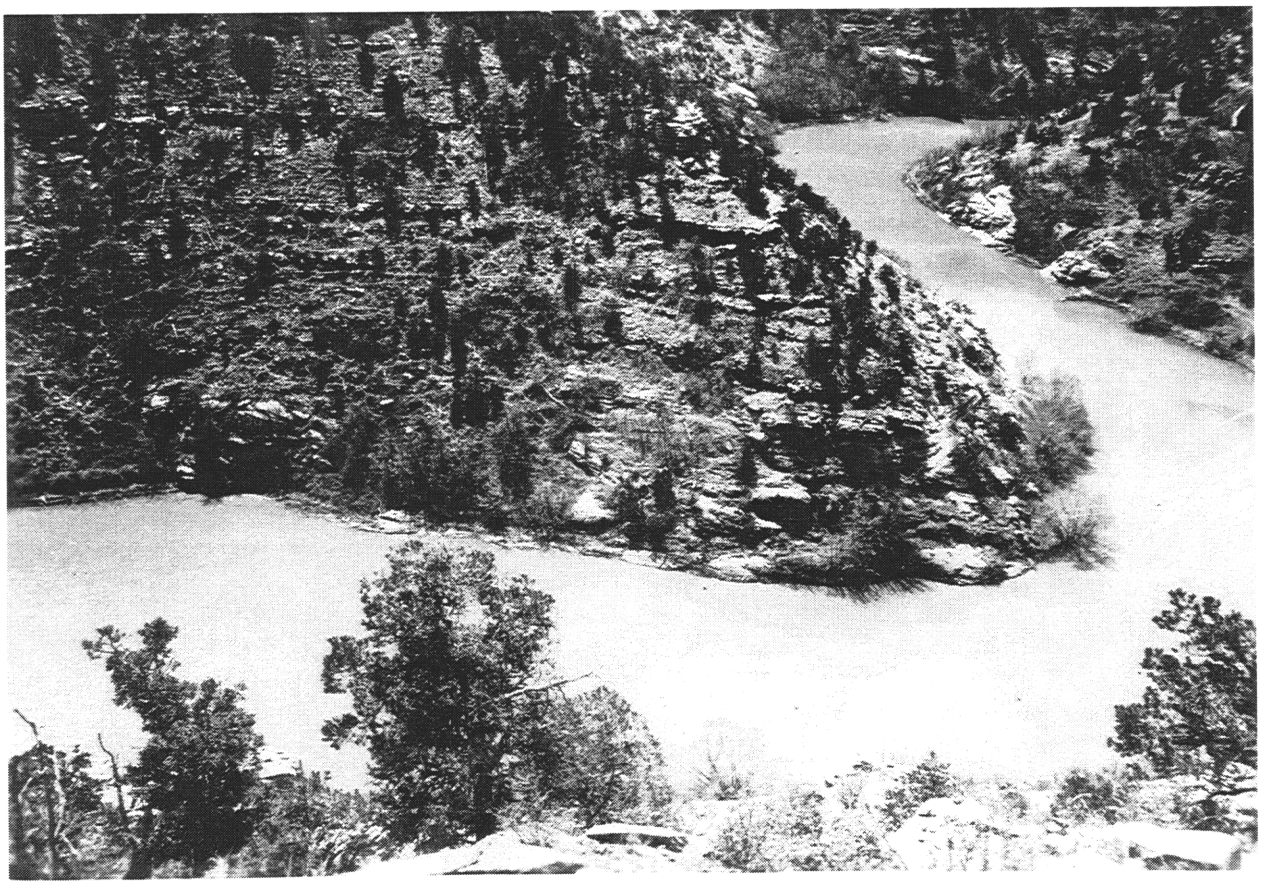

Figure 13a. "Walnut Canyon, lake about 1/4 mile above Santa Fe Dam, near Walnut Canyon National Monument," Paul Beaubien photographer, April 16, 1939. WACA Neg. 2608, Classification No. 551.48.

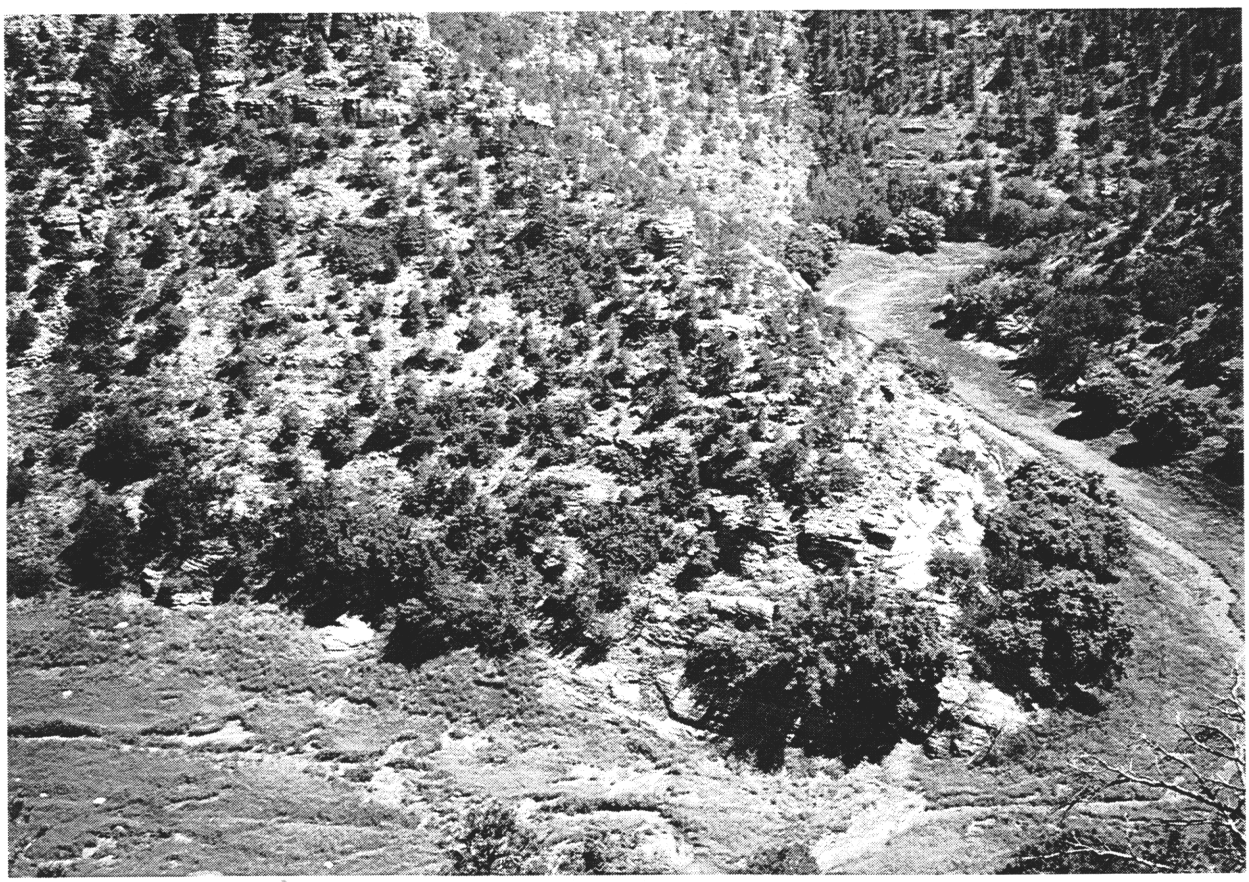

Figure 13b. View upstream and south from south-facing canyon slope approximately 0.4 km (0.25 mi) above Santa Fe Dam, August 1985, Walnut Canyon National Monument, Arizona.

CONCLUSION

Results of the photographic comparisons agree with results of the literature search. Due to the lack of evidence that proves Walnut Creek was a perennial stream prior to construction of the Lake Mary Dams in 1905 and 1941, the drainage can only be considered intermittent. Water flows in the drainage only following heavy winter runoff or summer thunderstorms. No observers at the turn of the century testified that water ran year-round in the Walnut Canyon drainage.

Unfortunately, no quantified measurements of vegetation have been made for the riparian zone. This lack of baseline data precludes comparison of pre- and post-Upper Lake Mary Dam measurements of cover. However, qualitative estimates can be obtained by the photo comparisons. Results of the comparisons show a dramatic increase in riparian and north-facing slope vegetation. Lack of severe, periodic floods down the canyon in the past 30 to 40 years has allowed the establishment of dense riparian vegetation in the normally dry streambed. Today, seepage and runoff from the steep canyon walls is sufficient to permit continued growth of north-slope and riparian vegetation.

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The cover photograph was taken October 4, 1935, in Saguaro National Monument by the first National Park Service photographer, George Alexander Grant (1891-1964).

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